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An Analysis of an Experimental Study Measuring the Effectiveness of Using Creative Problem Solving in the Living Environment Curriculum

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by

Steven C. Kolbert

An Abstract of a Project
in
Creative Studies

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Masters of Science

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Buffalo State College
State University of New York
Department of Creative Studies

ABSRACT OF THESIS

An Analysis of an Experimental Study Measuring the Effectiveness of Using Creative Problem Solving in the Living Environment Curriculum

The main focus of this experimental study was to identify how I used the aspects of Creative Problem Solving (CPS) in the Living Environment classroom and to compare its effectiveness to how I previously taught the course using traditional teaching methodologies. The research conducted included: 1) A qualitative analysis comparing the performance of students taking the Living Environment course during the 2002-2003 and 2003-2004 academic school years when I used traditional teaching methods to the 2004-2005 academic school year when I used CPS to teach the same curriculum; 2) A quantitative analysis of teacher feedback identifying the effectiveness of implementing CPS in the classroom; 3) A quantitative analysis of student feedback reflecting their growth in the ability to solve science problems through the use of CPS.

Quantitative data recording student performance were collected through the analysis of student Report Cards at the end of each academic school year. The data collected indicate that students who took part in the experimental group (classes where CPS was used) scored higher averages in the 2nd, 3rd, and 4th marking periods. These students also maintained a higher overall average, achieved higher Regents Test scores, and attained a higher level of Mastery on the Regents Exam than did students in the control group (traditional teaching style). Finally, the experimental group completed the Living Environment curriculum in nine fewer days, thus enabling them to have additional review time upon the conclusion of the school year.

Qualitative feedback from the teacher indicates that students who used CPS in the classroom were able to think more creatively and independently. Students were able to use CPS to solve a wide array of problems thus resulting in improved classroom participation, increased motivation, and increased security in sharing ideas. A positive learning environment was created that fostered the expansion of creative horizons in individual students, and promoted a feeling of trust and respect in the classroom.

Qualitative feedback from students indicates that using CPS gave students ownership over the learning process and empowered them to solve problems inside and outside of the classroom. They believed that CPS made the class fun, thus stimulating their creative abilities. Students reflected an improved self-confidence and motivational level when confronted with difficult situations because of their newfound ability to work through the stages of CPS in order to generate ideas and develop a working process plan. Using CPS in the classroom provided students with the opportunity to bring their own interests into the classroom and invoked a sense of academic freedom that was otherwise unfelt in other academic arenas.

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Why I Chose To Use Creative Problem Solving In My Science Classroom

When I began my teaching career I had a clear picture of how I wanted my classroom to function as a whole. I believed, and still believe, that the purpose of learning is for an individual to construct his or her own meaning of scientific content, not to just memorize the right answers and regurgitate someone else's meaning. By learning student's background information and understanding the individual learning styles of each of my students, I wanted to use scientific inquiry within the classroom to provide students with meaningful experiences that they could use to construct an understanding of the world we live in. I planned on using Constructivism in the classroom to allow me to help students make connections with scientific material by analyzing, interpreting, and predicting information. I wanted to be flexible in my teaching style, using various

approaches, in order to facilitate the different learning styles within my classroom. I hoped to rely heavily on open-ended questions, inquiry activities, and extensive dialogue among students to promote the life long learning skills that are required to develop productive citizens in the future. As my first years of teaching developed, I learned that students had not acquired the skills required to execute the game plan of my ideal classroom setting, and that none of the courses I had taken in college would prepare me for the trials and struggles I encountered when I tried to implement inquiry and constructivism in the classroom. Therefore, a chose to pursue a Masters Degree in Creative Studies in order to educate myself in the Creative Problem Solving (CPS) process so that I could teach and implement this process in my classroom to prepare students on how to solve scientifically based questions or problems, and to help facilitate the CPS process so that they could take the problem solving skills they would acquire in my classroom, and apply them to real life problems they will encounter throughout their life. In my early educational experience within this field, I have learned and tried to implement the foundations of this process in my classroom.

Literature Search: searches included the use of these key words to examine literature based in this topic area. Creativity and science, creativity in the classroom, teaching creativity, benefits of teaching creatively, what is creativity, how to teach creativity.

Where Searched	Number of Searches	Number of Resources Identified
CBIR	17	36
Creative Studies Library	4	1 Master's Project 4 Disney Partnership Videos on Creativity in the Classroom

Academic Search Premier (full text journal search)	1	56
Google Search	1	127 resources observed, including 7 creativity websites
Creative Studies Library Search	1	8 books read

Why Creativity Should Be Taught In the Classroom

Ruscio and Amabile (1999) studied the opinions of school administrators and found that developing problem solving skills is often regarded as the primary goal of the education process. It is believed that there is an increasing emphasis on the importance of promoting general thinking and reasoning skills that will help students solve novel and unusual problems, but in my experience, the educational process has failed to achieve this goal. Early on, children tend to be creative in their actions and the way they play, searching for answers to what is out there for them in the world. Hinson writes, "Unfortunately, this creative nature diminishes over time. Most teachers want and expect children to conform to a predetermined set of behaviors" (Hinson, 1998, p.25). It is this conformity that has undermined the creativity of our students, and failed in allowing them to solve their own problems, and it is this conformity that has created pressures that stifle the creative development of many students. It has been shown that creative thinking is a natural ability, which can be fostered through the proper instructional experience. However, the educational implication has proven that creativity has been stifled by

current teaching methodologies but, if we allow our students to discover their own personal creativity through the use of inquiry, inventing, and discovery then the positive ramifications may be endless because of creative problem solving's concrete, manipulative nature (Ebert & Ebert, 1998). My goal is to teach the art of creative problem solving (CPS) to my students by teaching them how to relax, that it is trial and learn, not failure, by creating an environment conducive to the CPS process, and to teach students the steps involved in the CPS process.

In our current fast-paced, ever changing society teachers are bound to face unique problems everyday in the classroom setting. Davis (1999) held that one of the most effective and teachable strategies to overcome these problems is CPS. It is meaningful, therefore, that schoolteachers learn how to implement and facilitate CPS in the classroom in order to observe the perceived impact CPS will have upon our students.

There are a number of other additional scholars who also maintain that creativity should be an essential component in the daily lives of human beings (in my mind, students). Sternberg and Lubart (1999) stated "creativity is a topic of wide scope that is important at both the individual and societal levels for a wide range of task domains" (p.3). Treffinger, Isaksen, and Dorval (2000) held that the importance of studying creativity is becoming important for individuals, groups, and organizations. In terms of the importance of creativity in an organizational setting, such as the classroom, Carnevale, Gianer, and Meltzer (1990) implied that an organization's ability to achieve its strategic and developmental goals often relies upon how quickly the creativity of the individual can come into play. My perception, upon studying CPS, is that through the effective implementation of CPS tools within the classroom, students will eventually

recognize their own creative abilities and learn how to use the abilities to assist them in solving problems both inside and outside of the classroom.

Cropley (2001) contended that the educational system needs to nurture creative properties such as openness, flexibility, the tolerance for ambiguity, and the ability to produce novelty. Torrance and Meyers (1970) pointed out that people fundamentally prefer to learn through CPS and creative activities. Furthermore, Torrance and Meyers (1970) stated that more concepts and content could be learned more effectively and efficiently through creative means rather than by authority or memorization. Puccio and Murdock (2001) insisted that it be significant for schools to nurture the creative thinking skills of today's student in order to prepare them to join the workplace and so that individual organizations can remain competitive. Guilford (1992), one of the pioneers in the field of creativity, maintained that all of all the consequences of various actions on creativity, those related to education "undoubtedly have the greatest and most enduring social impact" (p.72). Hinson (1998) writes, "only a strong creative ability will provide the means for coping with the future" (p. 24).

What Is Creativity (Creative Thinking)

When called on to identify what creativity is and what types of teachers are creative, eccentric and charismatic figures such as Robin Williams in *Dead Poets Society* or perhaps Jaime Escalante in *Stand and Deliver* may come to mind. We may think of the teacher who dressed up in costume to teach history lessons or used outlandish materials to help experiment and identify the relevance of content material. But what is creativity? Hinson (1998) defines creativity as "power." Creativity allows people to solve problems make discoveries, and change our perception of people, places, and things. It is the core

of freedom and opportunity" (p. 24). Davis (1999) defines creative thinking as the mainstay of creativity and that creative thinking is a lifestyle, a personality trait, a way of interacting with other people and a way of living and growing. According to Davis, living creatively is developing your talents, tapping your unused potential and becoming what you are capable of becoming. Sisk (1989) defines creativity as developing sensitivity to problems of others, problems of humankind, and having the ability of using your own imagination to solve these problems.

> Ritchhart (2004) describes teacher creativity as an:
> approach to content that is directly related to a teacher's insight into his or her own subject matter. A teacher's understanding of and passion for ideas and creativity reveals itself in a curriculum in which the subject matter is organized in a way that facilitates connections, encourages excitement, and makes learning a powerful endeavor. (p. 34)

He writes that creativity will happen if teachers continually ask themselves "how can I make this content more engaging and meaningful? How can I teach this in a way to help students interact with the content in a new way?" (p. 34)

Hinson (1998) further expands on his definition of creativity by relating it to a two-step process. The first step involves the discovery of ideas that are new, original, or novel. Ideas are discovered through the exploration of your imagination, using brainstorming, or other divergent thinking tools. He writes "the ideas generated during this step lead to new discoveries" (p. 24). His second step to define creativity involves the testing and examining of new ideas through problem solving and trial and error. This approach requires a hands on approach where creativity will flourish when the person becomes actively engaged "in doing, making, or producing- not merely thinking" (p. 24).

Working in direct relationship with Hinson's definition of creativity being a two-step process, Finke, Ward, and Smith (1999) showed that when an individual thinks

creatively, his or her mind will go through two distinct phases, the generation and exploration phases. In the generation phase an individual will come up with multiple options for solving a problem and in the exploratory process the individual will analyze and evaluate the options in order to select the best possible option for solving the problem.

Onda, a Japanese scholar, also held a similar viewpoint on creative thinking. Onda (1994) pointed out that creative thinking is a process that involves both convergent and divergent thinking. He defined creativity as something that "consists of creative abilities that produce something original and valuable and creative personalities that support the abilities" (p. 99).

Several other creativity scholars also support the importance of divergent thinking as an essential component to creative thinking. Guilford (1977) maintained that the abilities most related to creative thinking come in the operational category of divergent production and transformation. "Without either or both of these features being involved in thinking, we cannot say that creative thinking has taken place. These abilities make essential contributions" (Guilford, 1977, p. 160). The importance of divergent thinking in creative thinking was also examined by Treffinger, Isaksen, and Dorval (2000) who also viewed creative thinking as a direct product of divergent thinking during the idea generation phase. They stated that in the process of creative thinking "we begin at a single point or with a single question, but extend our search in many different directions, generating a wide variety of new possibilities" (p. 7).

In conclusion, from a teacher's standpoint, creativity or creative thinking should involve both the process of idea generation and idea selection. Teachers should shift

themselves out of the focal point of a lesson and encourage students to bring their own thoughts, questions, and sensibilities into the classroom in order to promote the development of creativity in the classroom. In order to accomplish creativity in the classroom a teacher should use effectively the divergent and convergent tools that comprise the CPS process.

Steps a Teacher Should Take to Promote Creativity in the Classroom

I. Relax

Goldsmith writes (2001), "The best way to re-open the filter to creativity is to relax" (p.78). It appears that students are caught up in being judged by their successes and failures, and when they do fail, or cannot come up with a solution to a problem, they shut down in fear of being criticized for something they cannot do, or cannot understand. They feel pressure from their family, friends, and teachers, and if the pressures become too great, their self-esteem, confidence, and performance levels all go down. Therefore, my primary goal will be to teach students how to relax and have fun in the classroom because when you are relaxed, you will enter the realm of gaining and accessing insight, intuition, and inspiration. In order to release daily stresses and pressures, I will engage my students in a daily ritual that will lead them to their creative zone. I will engage them in the Tense/Release and mini-vacation exercises that will coax creativity, not force it. "Instead of complaining and worrying, students will see problems as creative opportunities that give us a chance to grow and improve" (Goldsmith, 2001, p.78).

II. Remove the Word "Failure"

Working in a classroom scattered with inclusion/special education students, as well as educationally challenged students; failure seems to be a word that has followed

them throughout their entire lives. My next goal in establishing the CPS process in my classroom is to remove the word failure from their vocabulary. Students must learn that all people make mistakes, but these mistakes are just "results that you hadn't anticipated" (Firestien, 1996, p.150). Students must realize that the unanticipated mistake is an opportunity that we must learn from, and become more successful. Firestien writes, "It is probably advisable to change the idea of 'trial and error' into 'trial and learn'" (p. 151). Failures represent opportunities to reflect on whether or not the direction we are going in is the right direction. The tell us whether to keep going, or take a step back and redefine where we want to go by finding alternative solutions. Look at each mistake as an opportunity to learn, take two steps forward, and identify that mistakes present us with a new opportunity to grow and escape criticism and fear. Instead of grading students on a question-by-question basis, I will evaluate them on areas of content and scientific skills they acquire throughout a unit. I will apply the mistake quotient to their current work, and tell them "Remember, if you're not making some mistakes, you're not making any discoveries" (Firestien, 1996, p.155).

III. Positive Learning Environment

Parnes (1991) also provided me with useful information for conducting a creative environment within my science classroom by identifying the necessity of creating a psychological safety and psychological freedom in the classroom in order to foster creativity. If teachers allow students to be free, to feel, and to think about their own perceptions of science by working with a hands on approach to learning, they will give students a sense of responsibility to themselves, and their achievement. In short, we must allow students to take ownership of the learning process in order to bring about

constructive creativity in the classroom. Parnes (1991) noted that deferring judgment is essential to foster the creative environment in order to break the habit-response, or thinking along the pre-directed channel. Parnes identifies safety in the classroom as:

> When a teacher, parent, therapist, or other facilitating person permits the individual a complete freedom of symbolic expression, creativity is fostered. The individual is as free to be afraid of a new venture as to be eager for it; free to bear the consequences of his mistakes as well as of his achievements. It is this type of freedom responsibly to be oneself which fosters the development of a secure locus of evaluation with oneself, and hence tends to bring about the inner conditions of constructive creativity. (p. 139)

By creating a positive learning environment in my classroom, I have tried to let my students explore science to find how scientific content relates to their own life. By tying in personal experiences, a student cannot be judged upon their perceptions of new material if it makes them think or feel a certain way. Therefore, I emphasize to others that we shouldn't judge those around us for their answers, or their questions. By doing this I believe that I've accomplished openness in the classroom, leading to an abundance of associations between my students and content material, and have left my student's with a more confident approach into how to solve problems and achieve success. Without knowing it, I have instilled some of Parnes ideas and foundations for creativity in my classroom, and have achieved success as a result.

> Hughes (2003) writes: … innovation requires a style of organizational behavior that is comfortable with new ideas, change, risk, and failure. Creating an environment that is tolerant of mistakes is difficult. It must be made clear that mistakes are acceptable if they are based on solid thinking, enhance learning of what will not work, and are caught early before the damage is severe. (p.11)

IV. Freedom and the Positive Learning Environment

Students must be evaluated on innovative thinking styles and solutions, not only on the easy grading measures found in tests, quizzes, and homework. As a teacher it will

be my goal to create an environment based on student freedom to explore their wild and crazy ideas and to give students flexibility in finding solutions to their problems. I will give them more freedom in choosing classroom activities and assignments based on their own interests, while still meeting the requirements set forth by New York State. This will enable the students to become an integral part of the entire classroom process, from goal setting, to daily activities, to how they will be measured on their performance while attaining the required content material. The atmosphere will be relaxed, contain humor, as well as life lessons that will help them become productive members within the community. In essence, I will try and establish various organizational characteristics that will contain a climate marked by cooperation and collaboration across the board. "Innovation will be prized, and failure will not be fatal" (Firestien, 1996, p.179).

V. Trust and Respect as a Component of the Positive Learning Environment

Gass (2000) introduces the concept that traditional ways of teaching form the high school to the university level sacrifice the freedom to err for high academic standards, thus inhibiting the development of creative problem solving skills. He points out that students understand that to think creatively is to risk error, and students would rather not based on the emotional effect not intellectual effect that failure may bring. Gass (2000) found that students would rather think creatively or risk their safe environment with a stranger rather than the teacher themselves. Therefore, the environment that has been developed is seriously flawed and the teacher will be unable to help the student to learn and think creatively. Thus, he identifies that trust and respect are the central figures in education and the promotion of creative thought. In short, mistakes must be worth bragging about.

> Everyone has unique knowledge and experiences that can be tapped into, given the proper environment. The environment must be free flowing and nonjudging to take people through the mental blocks that have been established in early childhood. These mental blocks are associated with the risk of being wrong. Many educational processes give rewards only for getting the right answer, not for experimenting with new approaches or exploring the risky and unknown. (Hughes, 2003, p.12)

Torrance and Meyers (1970) emphasize that "creativity, even the serious kind, - is facilitated when one is able to regress occasionally – to laugh, to be childlike, to be dependent to fantasize" (p. 248). They identified that a key component to creating a positive classroom environment lies within the student-teacher relationship. Teachers should develop a relationship based on love and concern for the well being of the student, teachers should be strict, but not cruel with their punishment, and should make students feel like they are on their side. The teacher must be willing to permit one thing to lead to another, and should not be disturbed when a pupil asks an unexpected question or proposes a surprise solution to a problem. If these conditions are found within the classroom environment then creativity and creative thinking will flourish.

Piltz and Sund (1968) identified that "there is no field of human knowledge that affords a greater outlet for creativity than science" (p. 15). They relay the idea that science should demand innovation and encourage original thought and action. Science should no longer be rote memorization, rather teachers should deal with the nature of science through creativity by promoting the structure and relevance of science to real world applications. But, in order for creativity to flourish in science, the teacher should create an atmosphere that allows and permits challenge and does not hinder the creative thinking process. The classroom must be a free environment with minimum pressures,

stresses, and obstructions. This will ultimately create a trusting learning environment that stimulates creative thinking.

VI. Cooperative Learning and the Positive Learning Environment

As a teacher and facilitator it will be my role to remind my students that they are making their own trail, sometimes the trail will be traveled alone, sometimes with a partner, and sometimes as a group. In order to facilitate the CPS process in students with varying abilities and disabilities, students must work alone, with an assigned partner, or with a group of partners. Working along this level allows students to engage their own thought process, as well as using a team amongst individuals who have different thinking styles based on their own experiences. "Working in different settings will allow individuals and groups to expand their horizons, break down their barriers, become more

apt in solving classroom problems, and create a classroom theme based on achievements and success stories" (Giangreco, 1993, p.128).

VII. Praise and Motivation and the Positive Learning Environment

Part of creating an environment conducive for problem solving will be to create an atmosphere based on praise and motivation. The real problem I encountered throughout my first year of teaching was how do I get the students to do what I want them to do within the scientific inquiry method. In taking this course, I realized that my approach was way off base. I tried pointing out the mistakes and asked the students how to correct them, when really, to get them to do what was needed; I should have been praising their successes. When I work to change student behaviors in the future, I will need to "use a praise-to-criticism ratio of 8 praises: 1 criticism" (Firestien, 1996, p.121)

Farnham and Davis (1994) write, “It is important to recognize and reward – the right way. Allow you’re workers to take credit for the work that they’ve done. When you praise them for a job well done, the creativity and innovation in the work place will increase tenfold” (p.18). It has been found that when a teacher or boss invokes forms of negative criticism or negative feedback to increase worker performance, the worker performance will actually suffer. Students who are approached this way will become defensive, angry, and tense, and in effect will shut down their performance. After reading these studies, I’ve practiced saying positive things and even pointing out positives even when there may not have been one from a teacher’s point of view, and I’ve found that students are enjoying my class more, they want to be there, and they are more motivated to learn. This praise and motivation has created more productivity and creativity in the classroom (based on the greater variety of questions and solutions generated) and has allowed the class to move at a faster pace.

VIII. Resisting Conformity

Feldhusen and Treffinger (1985) pointed out that one of the essential focal points of creating a positive class climate is to get students to become receptive to new ideas and to resist conformity. In order to get students to remove their fear of failure or resist the peer pressure involved in generating unique ideas teachers must promote a classroom that encourages mutual respect and acceptance. Feldhusen and Treffinger (1985) identified key components that a teacher must include in his or her own classroom if unusual ideas and thinking are going to be accepted as the norm. They include: support and reinforcement of student development of new and unusual ideas, teachers must use failure to promote the positives involved in the inquiry process, allow students additional

think time in order to use divergent thinking to generate new ideas, promote and foster student choices in daily lesson plans, and most importantly develop a climate where all participants listen and laugh together, not at one another.

IX. Identify the Heart of the Problem

Another essential element that a teacher must have in order to stimulate creative thinking in the classroom a teacher must find new ways to ask questions in order to have students identify the heart of the problem. Getzels (1975) writes "the formulation of the problem is often more essential than its solution" (p. 301). Over the past 2 years as a teacher I can relate to this point because in many instances I've had to reword a question that I'm asking, or a question that is found within a lab exercise or test, in order for students to generate better ideas on how to find or generate a solution. "To raise new questions, new possibilities, to regard old questions from a new angle, requires creative imagination and marks real advance in science" (Getzels, 1975, p. 301). Therefore, the quality of the problem posed is crucial in understanding the foundations of science and any other activity that may require thought. In education, it seems apparent that to gain quality solutions to a problem, the teacher must ask quality questions. As a teacher I must start having my students identify where problems exist in a lab exercise, activity, or test in order to identify a functional problem that will lead to effective and inventive solutions. In teaching we are too often caught up in the end result, did I teach the entire curriculum, or was all of the required content taught and explained. Instead, we should focus more on generating quality problems that will allow students to explore, and use their creativity, in order to develop their talents for solving problems. Also, we must give students the opportunity to tear apart problems we generate and deem important to our

curriculum, and allow students to generate problems that are more easily understood and identifiable to them, so that they can generate novel solutions, and gain more relevance to the material they need to learn and apply it within their own lives. Allowing students to redefine the question will in the end, result in a greater background knowledge development, and better ability to recall information over extended periods of time.

Feldhusen and Treffinger (1985) write that teachers should use divergent or open-ended questions in order to help students to gather facts, form hypotheses, and to test the information they have gathered. Questions should be formulated to get students to think and to get them to expect the unexpected. Feldhusen and Treffinger (1985) identified seven reasons as to why divergent questioning should be used by teachers in the classroom: to arouse interest and motivate students, to evaluate preparation and mastery of content material, to review and summarize, to assist students in developing relationships between learned concepts, to stimulate creative thinking, to seek out additional knowledge independently, and to evaluate achievement of goals and objectives of a lesson. Questions should be inherently related to discovery and they should be fostered through inquiry and the CPS process. They write "inquiry based questions and learning enhances creative performance by forcing the learner to manipulate the environment and produce new ideas" (p. 116).

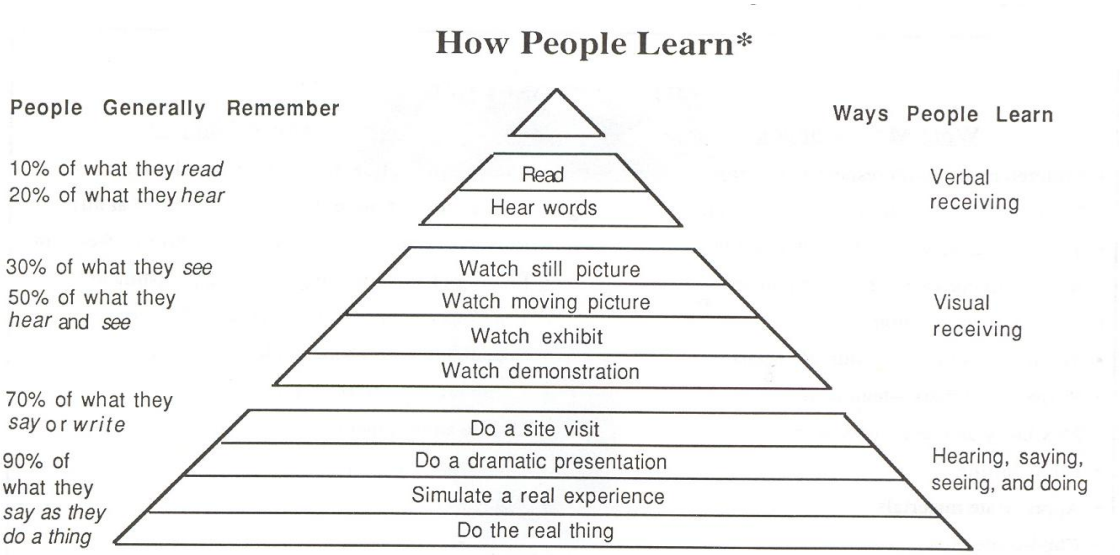
X. Diversify Teaching Methodologies

The final component that a teacher can use to promote creativity in the classroom is to diversify the methodologies we use in instruction. Piltz and Sund (1968) write that diversity in instruction will result in a greater number of children/students who reach their creative potential and begin to freely explore scientific phenomenon. Devito (1984)

believes that the function of teachers is not to uncover why some people are more creative than others, rather to find out how we can make more of us use and develop the creativity that we already possess. He believes that creativity can be nurtured and its development depends on the instructional methods introduced to the student. Teachers should start out simple with their instructional techniques, then move to more advanced techniques in order to reach students at different levels. Sisk (1989) makes teachers aware that creativity is made up of a large number of skills, attitudes, abilities and talents yet there is no sufficient method to measure creativity nor is there one single technique that teachers can use to nurture creativity in students. Teaching creativity must be a continuous process and educators must teach creativity by using novel strategies and altering the method in which we introduce material in order to enhance creative behavior in the classroom.

An important principle of learning, and its application to teachers altering their methods and techniques for instruction, is that people will learn best when they are actively involved in the learning process. Since people learn in different ways and how much they remember or retain from different teaching modalities varies, it is essential that teachers continually use multiple strategies to introduce content material in the classroom in order to promote active learning. Dodge (1993) introduced the following pyramid (See Figure 1) to help teachers identify the ways people learn and how much they generally remember.

Figure 1:



* Based on Edgar Dale, "Cone of Experience." (Adapted from *Audiovisual Methods in Teaching*, "Third Edition, Holt, Rinehart and Winston, Inc., 1969, p. 107).

Hermann (1988) presents his ideas of whole brained creativity in which the individual is encouraged to shift or move from one process to another until a creative act is completed. He stresses that it is important for educators to know more about the students preference for learning and that through gathering such knowledge a teacher can extend and improve the mental capabilities of the student in order to help student's realize their creative potential. Teachers should shift teaching styles in order to stimulate the different styles of learning that are present in a classroom setting. Left-brain learners are rational, cognitive and quantitative. They are organized, sequential, and procedural. On the other hand, right brain learners are visual, conceptual, simultaneous, emotional, expressive, and interpersonal. Since a classroom will be comprised of learners of different types and styles, it is essential for teachers to continually use diversity in instructional techniques to promote creative thinking in the classroom setting.

Poon Teng Fatt (2000) writes "the teachers of tomorrow at all levels of learning will need a more extensive repertoire of teaching strategies" (p. 9). He believes that if

teachers are going to be a source of innovation and problem solving they will have to seek ways to engage students in higher cognitive processes based on the breakthroughs in brain and human cognition research. He explains:

> teachers will need to adopt a 'balanced brain' approach in their teaching, that is, an approach that goes beyond testing merely students' ability to recall facts. Future teachers will need multi-skills in organization, communication, and human relations in order to participate in a new world of teaching and learning (p. 9).

Teachers should emphasize creative thinking during lessons by encouraging students to think creatively, search for their own answers by rewarding originality, and by themselves, continually alter their teaching style to facilitate learners of different styles. Poon Teng Fatt offered suggestions as to how creativity and different learning styles can be taught in the classroom setting. They include: allow students to design their own websites based on themes, thus being well-versed with the advancement of technology in society, engage students in thought-inspiring activities such as debates, get students to role play, encourage students to share their interests thus setting the tone for group work which will stimulate the generation of ideas and sharing risks, reward creativity whether it is a success or a failure (learning opportunity), and to remove the confinement caused by teaching or copying from the class textbook (pg. 10-11).

In effect, everything I've researched has allowed me to understand how to nurture creativity in the classroom. Part of scientific inquiry is interwoven into the creativity process, and I've been implementing some common practices that I will continue to implement as I switch into the CPS process as a teaching tool in my classroom. Some common tools that I will continue to use to nurture creativity in the classroom include: ask questions (based on divergent, open-ended questions designed to get more information); vary my routine (from lecture, to labs, to fun activities, to Q & A forums, to

student lessons, etc.), read and listen to a variety of material, network, reawaken the class sense of humor (although I have been criticized for using humor in the classroom), create an environment that encourages creativity, and to be passionate about my/the class future visions. New ways that I will nurture creativity in the classroom include: stop the action (I will give students 20 minutes of quiet/think time every Friday to reflect on the weeks activities to hopefully gain new insights into class material), develop creativity habits by teaching my students the CPS process, and to develop personal support systems for myself and my students.

Implementing CPS in the Classroom

Finally, after recognizing how to nurture and create a positive environment to spurn creativity in the classroom, I was now responsible to teach my students how to solve problems creatively. The task was strenuous because CPS has emerged through several decades of work by a number of developers and researchers. Alex F. Osborn developed the original description of CPS in 1952 and his work was modified and condensed by a number of his colleagues (Parnes, Noller, Isaksen, Treffinger, Miller, Vehar, Firestien) throughout the years. As a result of my participation and research conducted as a graduate student in the Creative Studies Program, I decided to utilize a combination of three modifications of CPS to use as an educational process in the classroom. In doing research for my Masters Project I was introduced to the work of Giangreco (1993) who performed a study on how to implement the CPS Method in the inclusion classroom. He came up with two different styles that I used and implemented through extensive practice. Table 1 shows tips towards implementing the CPS that I used when completing projects, or laboratory activities that required more imagination and

creativity in order to understand content material. Through these activities students normally encounter more problem areas and encounter more stumbling blocks; therefore, I believed this approach would allow them to come up with more comprehensive solutions. As a teacher and facilitator in the process I continually modeled the proper steps and procedures within the process and covered my room with flip charts, identifying the proper roles, goals, and steps of the CPS Process.

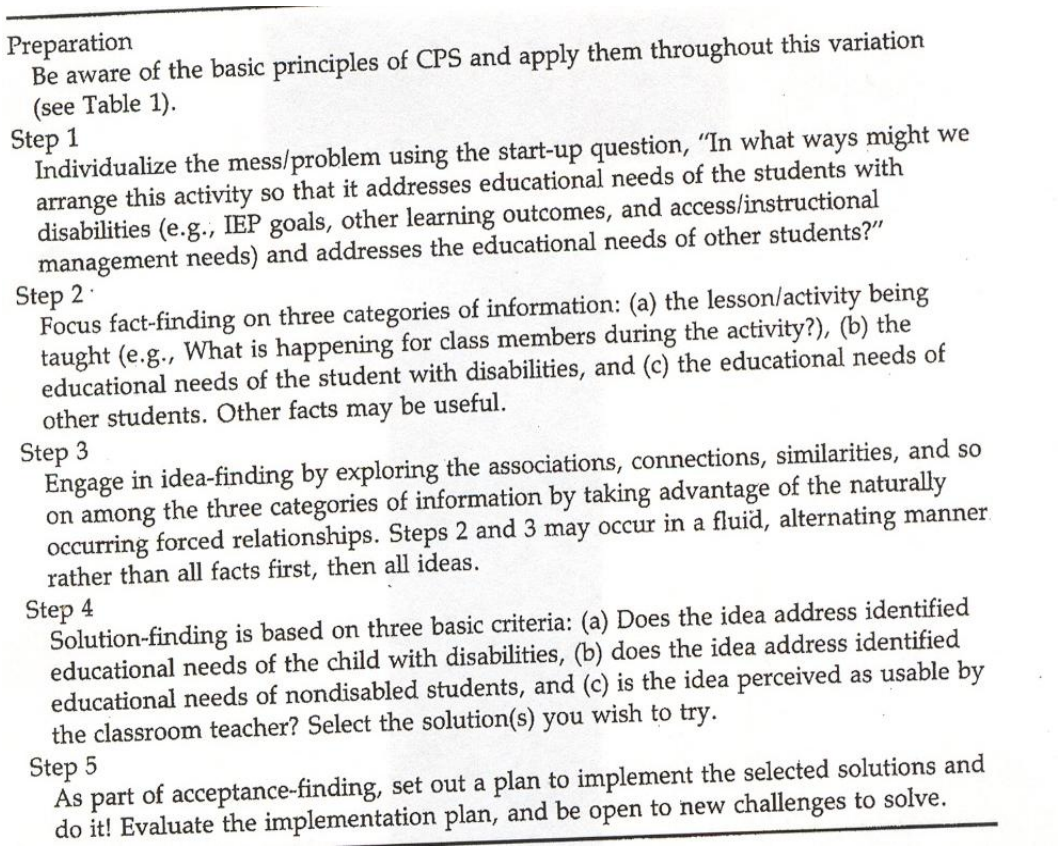
Table 2 represents the short focused option of the CPS process. This method was developed to assist in getting students involved with and practicing the CPS process on a daily basis. The short-focused option was generated for teachers when there is only a short time available to solve a particular challenge, but still provides students with the opportunity to practice the idea-finding and solution-finding phases of the CPS process. The short-focused option provides the teacher with the opportunity to involve a whole group setting instead of the individual setting that most current teaching styles access. I began practice of this method by using a variety of flash card activities designed to keep all students involved at all times, not just when they are called upon to answer one question out of the multiple questions asked during a 45-minute classroom session.

Table 1: CPS Process in the Inclusion Classroom (Giangreco, 1993, p.118)

1. Capture ideas whenever and wherever they come to you. Many of our best ideas are "free" and they often come to us when we're relaxed and not working on a problem. Record your ideas immediately.
2. Model openness and acceptance of ideas. Watch your verbal and nonverbal behavior. Much of how and what we communicate about ideas is expressed in the verbal and nonverbal ways we treat the ideas of others.
3. Redefine your problem in many ways. Ask yourself "why?" Many times we set out to solve the wrong problem. Challenge your assumptions.
4. Go outside the problem area. Look for connections for solving the problems from other areas. Ask yourself, "What ideas can I get for solving this problem from a completely different world?" Remember that the history of science is filled with breakthroughs in which two different worlds, originally considered unrelated, were combined to form a new idea.
5. Develop creative habits. When working on a challenge or opportunity ask yourself, "How else can I do this?" "What if?" "How can I use something that doesn't fit with this at all?"
6. Separate your imaginative thinking from your judgmental thinking. When generating ideas, don't criticize your ideas or the ideas of others. After you have generated a number of ideas, then evaluate them, but don't try to generate and evaluate at the same time.
7. Evaluate ideas by considering the Pluses or strengths of the idea first; then list the Potentials in the idea; then list the Concerns (PPC). When you determine your concerns about an idea, phrase your concerns as you would phrase a question or problem statement. This way your mind will immediately begin to look for ways to overcome the concern instead of disregarding the entire idea.
8. When working to solve a problem, set a quota of at least thirty to thirty-five ideas and strive to reach the quota. To get new ideas, it is important to stretch beyond the obvious ways for solving a problem. The creative person knows that there are many ways to solve a problem, market a product, discipline a child; the more ways you have of accomplishing your goal, the greater are your chances of doing it.
9. We are all creative, but it is important to realize that creativity requires practice and development like any other skill.
10. Look at problems as opportunities. Every "problem" we encounter has something to teach us. As Richard Bach, author of *Illusions* said, "There is no such thing as a problem without a gift for you in its hand. . . . We seek problems because we need their gifts."

From *Why Didn't I Think of That? A Personal and Professional Guide to Better Ideas and Decision Making* (pp. 6-7) by R. Firestein, 1989, East Aurora, NY: United Educational Services Incorporated.

Table 2: Short-Focused Option (Giangreco, 1993, p.124)



Preparation
Be aware of the basic principles of CPS and apply them throughout this variation (see Table 1).

Step 1
Individualize the mess/problem using the start-up question, "In what ways might we arrange this activity so that it addresses educational needs of the students with disabilities (e.g., IEP goals, other learning outcomes, and access/instructional management needs) and addresses the educational needs of other students?"

Step 2
Focus fact-finding on three categories of information: (a) the lesson/activity being taught (e.g., What is happening for class members during the activity?), (b) the educational needs of the student with disabilities, and (c) the educational needs of other students. Other facts may be useful.

Step 3
Engage in idea-finding by exploring the associations, connections, similarities, and so on among the three categories of information by taking advantage of the naturally occurring forced relationships. Steps 2 and 3 may occur in a fluid, alternating manner rather than all facts first, then all ideas.

Step 4
Solution-finding is based on three basic criteria: (a) Does the idea address identified educational needs of the child with disabilities, (b) does the idea address identified educational needs of nondisabled students, and (c) is the idea perceived as usable by the classroom teacher? Select the solution(s) you wish to try.

Step 5
As part of acceptance-finding, set out a plan to implement the selected solutions and do it! Evaluate the implementation plan, and be open to new challenges to solve.

From *Why Didn't I Think of That? A Personal and Professional Guide to Better Ideas and Decision Making* (pp. 6-7) by R. Firestein, 1989, East Aurora, NY: United Educational Services Incorporated.

As a result of my participation in CRS 559 I was determined to use the three basic building blocks identified as essential to CPS: Explore the Challenge, Generate Ideas, and Prepare for Action (Miller, Vehar, & Firestien, 2001). In combination with the CPS methodologies outlined by Giangreco, I determined the CPS Process outlined by Miller, Vehar, and Firestien was also effective and practical to use within the confines of the science classroom. They modified the process in a way that it could be easily understood and used because the components and stages were changed into plain English (See Table 3).

Table 3: The Whole Picture developed by Miller, Vehar, and Firestien

CPS process in full detail

The CPS process breaks down even further with one or more stages in each component. The entire CPS line-up has six stages, one for each column heading:

CPS stage	Identify Goal, Wish or Challenge	Gather Data	Clarify the Problem	Generate Ideas	Select & Strengthen Solutions	Plan for Action
when to start	You want to create, invent, solve or improve something.	You want to explore the facts, feelings and data around the issue.	You want to pinpoint the right problem to solve.	You need novel, useful ideas to solve your problem.	You want to turn promising ideas into workable solutions.	You want to implement a solution.
statement starters	I wish... It would be great if...		How to... How might... In what ways might... What might be all the...		What I see myself (us) doing is... *for criteria:* Will it? Does it? Is it?	
sample questions	What are some goals, dreams or visions you'd like to begin or accomplish this year? What do you wish worked better? What challenges do you face? Who's been on your mind lately? Why?	Give a brief history. Who's involved? Why is this a concern? Why's it an opportunity? How do you own this? What's been thought of or tried already? What is the ideal outcome?	Why? Why else? What's stopping you? What else?	What can you combine, substitute, modify, eliminate or rearrange? What ideas can you get from other objects, worlds or situations?	What do you like about it? What opportunities or potential spin-offs are there? What are your concerns? How might you overcome them?	Who might assist? Who needs to be convinced? What resources are available? How can you get acceptance & enthusiasm for your idea? How could you pre-test the solution?
tools	Generate statements of your goals, wishes and challenges.	Brainstorm on data gathering questions	Brainstorming "Why?What's Stopping You?" Word Dance	Brainstorming, Brainwriting, Forced Connections, Visual Connections, Excursions SCAMPER, Idea Box	Brainstorming	Brainstorm on assisters/resisters and action planning questions
	Check for ownership, motivation and imagination	Hits	Highlighting (hits, cluster, restate)	Highlighting (hits, cluster, restate)	Praise First, Evaluation Matrix, Card Sort, Targeting	Hits
outcome of stage	A statement of the goal, wish or challenge that begins with "I wish..." or "It would be great if..."	A list of key data about the goal, wish or challenge	A well defined statement of the problem	An idea or a selected list of ideas that will solve the problem	Well developed, detailed and improved solutions, phrased: "What I now see myself (us) doing is..."	A plan for implementing solutions with a list of who does what by when, reporting completion to whom

From: Miller, B, Vehar, J. & Firestien, R. (2001). *Creativity unbound: An introduction to creative process*. Williamsville, NY: Innovation Resources, Incorporated.

In addition, I implemented brainstorming in my class based upon the research and methods outlined by Om Goyal (1999), which include: self-brainstorming, partner brainstorming, and group brainstorming. The basic principle behind each method includes these principles:

> List as many ideas as you/partner(s) can, don't take a negative attitude toward any idea, put together the so called old "impossible" ideas, toy with the ideas on the list, combine ideas to generate new ideas, try to break an idea into parts in order to generate many new ideas, and challenge ideas in order to generate a new set of ideas or draw up scenarios to develop ideas subsequently (Goyal, 1999, p. 181-183).

As a result of using brainstorming in my classroom, students started to rely on themselves and each other for answers to questions, without searching for advice and guidance from me, the teacher. Students previously looked to me for the fast and easy way out of finding a solution for their problems, but now after using brainstorming in the classroom, they began to work independently, coming up with their own answers to problems they would never have solved before. In effect, by implementing and nurturing a CPS process that involves brainstorming, I've began to change and redevelop the lives of students who were previously categorized as "dumb" and "stupid." By erasing these self-doubts, I increased each student's confidence, self-esteem, and started to make learning fun again.

Puccio and Murdock (2001) maintained that creative thinking "can be taught and enhanced through such methods as Creative problem Solving" (p.71). I chose these methodologies because they are closely related to one another. They present the process as occurring in stages that includes the generation of options and the selection of appropriate options in order to foster creative thinking. CPS also provides a wide range of convergent and divergent tools (See Appendix A) that helps students establish a balance

between generating numerous ideas and making proper choices and decisions about which ideas to choose when solving a problem. Isaksen and Treffinger (1985) compared CPS to a large bucket, thus treating each one of the stages of CPS as a large bucket that can hold many tools. The analogy also suggested that the components, stages, and phases of CPS might be used in a variety of orders or sequences based on the needs of the problem solver, or in my case, the needs of the content being introduced on a daily basis (Treffinger, 1988). As an educator who believes in the constructivist movement in education, CPS provided me with a flexible approach that would enable students to become life long learners and personalize their understanding and application of scientific content.

Benefits of Using CPS in the Classroom

In some of the earliest studies of the advantages of using creativity or the CPS process in the classroom, Parnes (1987) lists some of the benefits students gained in his research during the Creative Studies Project, where a four-semester long empirical study was performed using an experimental group mainly used creativity training (CPS) and a control group with no creativity intervention. The findings of the experiment include: the experimental group (CPS training) was better able to cope with real-life situational tests, the experimental group performed better at applying their creative abilities in tests within English courses, the experimental group improved significantly in testing areas from year to year, the experimental group was more productive in non-academic achievement areas calling for creative performance, and the experimental group reported large gains in own creative, productive behavior.

Isaksen and Treffinger (1985) identify support for using the creative learning approach to the curriculum in that the benefits "range from developing independent, self-directed learners to those concerned with providing a more humane type of learning" (p. 425). Treffinger (1988) summarized the rationale for creative learning because: it helps learners to be more effective when teachers aren't around, it provides the opportunity to solve unexpected future problems, it may lead to powerful consequences in our lives, and that creative learning can produce great satisfaction and joy. Isaksen and Treffinger (1985) also note "creative learning transcends mere recall, providing the learner to synthesize and apply previously learned material to novel situations" (p. 426).

Ritchhart (2004) identifies four benefits of using creativity in the classroom. They include: motivational benefits, social benefits, efficacy benefits and performance benefits. "Creative classrooms also foster a joy of learning that provides an internal motivation for learning" (Ritchhart, 2004, p. 4). By allowing students to have fun in the classroom, creating a positive learning environment, and allowing students to share their emotions in the classroom fosters creativity and as a result promotes motivation. He acknowledges that by allowing students to share their interests and ideas, while at the same time respecting those opinions and ideas of those around you, helps promote an environment based in trust and respect that will cultivate the benefits of both the individual and group within the social context of the classroom. Ritchhart writes:

> Efficacy relates to one's sense of effectiveness within a particular situation or domain. It addresses the question: Can I be productive here? In creative classrooms, students gain a sense of efficacy as they learn how to learn and develop the habits of mind that support good, productive thinking. (p. 5)
>
> In creative classrooms, students not only enjoy learning, they learn more.

> Creative classrooms often explicitly focus on real-world applications and connections such as modeling actual phenomena, immersion in the community, and so on. This focus provides students with the opportunity to put their skills and knowledge to use in a particular context. At the same time, teachers often attend directly to the issue of transfer by asking students to apply their understanding in new circumstances. These factors—motivation, engagement, application, and transfer – all work together to boost the overall performance and understanding of students. (Ritchhart, 2004, p. 5)

Muneyoshi (2004) conducted a study of alumni and current students of the International Center for Studies in Creativity who have taught in primary and secondary schools in order to investigate how teachers use CPS in the classroom. In his study he identified the perceived impact the use of CPS has had upon students in the classroom. In Muneyoshi's research (2004), the research consisted of responses from 22 participants, he determined that the use of CPS had this effect on student attitudes: an improvement in classroom participation, students improved their way of dealing with problems, students became more active (took ownership) in learning, a positive attitude towards creative problem solving, students looked forward to being critiqued and critiquing, and that students were more eager to take risks.

Muneyoshi also identified the perceived impact on student behavior as follows: students saw things more affirmatively, students were more cooperative with each other, students began using CPS in their own daily lives, and students became more patient and took more time in completing activities.

Muneyoshi (2004) also found that CPS had an impact on student feelings by: level of student motivation increased, students gained strength and confidence in their individual abilities and performance, and the students believed that their opinions, ideas, and expressions gave students independence and empowerment.

Finally, Muneyoshi's (2004) study involving 22 participants uncovered that using CPS in the classroom as a teaching process can: create an environment in which the students feel safe, create a classroom that is more positive, special-need students have success with open-ended questions, and that students "moved out ahead as producers of products and knowledge" (p. 64).

How Creativity in the Classroom can be Inhibited

Dodge (1993) identified certain characteristics of a classroom that will cause a reduction in creative output, reduce the effectiveness of the use of CPS in the classroom, and minimize the overall achievement of learning within a science curriculum. This list includes, but is not limited to these inhibitors of creativity: punitive discipline, physical or emotional remarks or actions that damage a child's self-esteem, inappropriate behavior on the part of students or adults, unnecessary clutter, disorganization, and long waits.

In a study conducted of elementary school teachers by de Souza Fleith (1998), teachers identified what they perceived as the major inhibitors of creativity. The study determined that a poor classroom environment that diminishes creativity has these components: prevents the sharing of ideas between or amongst students, ignores ideas, discourages wrong answers, and allows for the acceptance of only one answer. Teachers identified that drill sheets and worksheets were poor activities to do if creative output is desired. A teacher that is controlling, puts a time constraint on tests and activities, is over structured, sticks to a schedule, and lacks time management contains personal teaching traits that can extinguish student creativity in the classroom.

In the same study, de Souza Fleith (1998) interviewed 41 students to determine what they thought prevented creative output in the classroom. Her findings showed that a

teacher that is too structured, strict, and punitive will restrict the creative output in students because they fear getting in trouble. Students also desired more time to complete assignments and free time in order to explore individual areas of interest. Most of the students felt that teachers were burdened by time because of all of the material they have to cover, and they believed time to be their biggest constraint in the development of creativity. In addition, students felt that technology should be incorporated to a greater extent in the form of games and Internet access in order to keep up with the advancement of technology in society. Students also expressed boredom and unmotivated behavior when assignments are too long, have too many directions, or during long lectures that do not involve class discussions.

Conducting the Study

I. Participants and Where the Study was Conducted

For three years I conducted a study designed to investigate and to compare the effectiveness of using CPS versus a traditional teaching style in the Living Environment classroom (Room 115) at Depew High School. The participants in the study consisted of 10^{th} and 11th grade students who were assigned to my classroom and were unaware of the different classroom settings and teaching styles they were exposed to in order to complete the study. The control group of the experiment consisted of 55 (31 female and 24 male) Living Environment students (including special education and students of special needs) from the 2002-2003 and 2003-2004 academic school years. The teaching style used for the control group was a traditional teaching style that included: traditional lecture format, cooperative learning groups to complete laboratory activities and homework assignments, and a variety of assessment tools (tests, quizzes, projects, term

papers, lab reports, and homework assignments consisting of multiple choice and short answer questions) used to measure the progress of students as they advanced through the Living Environment Curriculum. The curriculum covered 9 topic areas: The Cell and Life Processes, Cell Processes, Genetics, Reproduction, Evolution, Ecology, Scientific Inquiry, and Laboratory Skills.

The experimental group consisted of 80 students, including special education and students of special needs, from the 2004-2005 academic school year who were exposed to CPS. I used a variety of convergent and divergent tools (See Appendix A for list and explanation of the tools) throughout the teaching of the curriculum consisting of the nine topic areas previously listed. I used the same assessment tools each year with a modification to the laboratory reports that students submitted. New York State requires students to fulfill a lab requirement (30 labs) in order to take the NYS Regents test at the end of the academic calendar year. For the control group they were given the labs previous to completing the experiment. The labs consisted of a title, procedure, list of materials, and a series of questions that students were required to answer based on the outcome of the experiment. The experimental group was given just a question that needed to be investigated or creatively solved. They were required to research the problem prior to conducting the experiment. The experimental group was then divided into smaller groups on the day of the experiment and each group was asked to utilize the CPS process to help them investigate and come up with a solution to the lab question. Upon completion of their designed investigation, the experimental group completed the same traditional lab report used by the control group to insure that the proper scientific material was covered and understood. Both groups were given the same lecture notes and

assessment tools. The only aspect of the study that differed between groups was the teaching methodology and process used to deliver the content material.

I was the teacher as well as the person who conducted the experimental study. I am currently a student in the Creative Studies Masters Program who is one course away from fulfilling the completion requirements. I am currently a science teacher at the high school level at Depew High School. I chose to do this experiment because of my formal training in CPS, to fulfill my interest in using CPS with high school students, and to determine if using CPS in the science curriculum would improve student performance throughout the year.

II. Establishing an Environment that Fosters Creativity

After researching how a teacher can foster creative thinking, I determined that I needed to establish the guidelines for making my classroom a creative environment before my study could be conducted. In research conducted by de Souza Fleith (2000) it was determined that a creative environment needed: time for creative thinking, rewarding creative ideas, encourage risk taking, allowing mistakes, offering free choices, encouragement of diversity, and little rote learning. Edwards and Springate (1995) suggested a teacher could establish a creative environment by doing the following: extending time for tasks, give students space, provide an abundant supply of materials, accept mistakes, and enrich student learning by bringing relevance to the content being covered. Craft (2000) provided these guidelines for creating an environment conducive to creativity: heighten creative awareness by teaching across all curriculums, offer time for exploration and play, promote risk taking in a non-threatening atmosphere, and to be flexible with time and space. Using these guidelines as a model, I devised my own

strategy to implement these ideas in order to establish a classroom that would promote my students creative horizons.

III. Introducing CPS

I started the course for the experimental group by introducing CPS methodologies before the course material could be introduced. The first stage in this strategy was to introduce a working definition of creativity to the students. I performed this task by showing my students a PowerPoint presentation that introduced definitions of creativity, Mel Rhodes' (1961) model of creativity, and the ground rules for divergent and convergent thinking (See Appendix B).

The second phase of my strategy required the teaching of the value behind clarifying problems students would encounter throughout the year. I accomplished this by showing my second PowerPoint presentation about the essence of clarifying the problem (See Appendix C). This presentation included: more definitions of creativity, what is the CPS Process, a warm up activity designed to set the tone for identifying the real problem, identifying the steps involved in CPS, identify broad and narrow problems, and an explanation as to why I was going to use CPS in my classroom. During this segment of teaching my students CPS I wanted to get my students to understand the importance of keeping things simple, looking at the entire picture, to broaden their perspective and scope of how they observe problems and their environment, and to learn how to "Explore the Challenge."

In the third phase of introducing CPS to my students, I showed a PowerPoint presentation outlining the importance of generating ideas during CPS (See Appendix D). This presentation included: tips for how to establish a creative environment, the roles

required during the generation of ideas, how students could spark their own creativity, and the rules for generating ideas. During this segment I reviewed the rules for divergent and convergent thinking, displayed my billboards that were hung within the classroom listing the rules for divergence and convergence, and engaged my students in an activity designed to practice each. At this time I emphasized the importance of generating an abundance of ideas to solve a problem and modeled how to choose the most promising idea by introducing success stories of how CPS was used in the real world. In addition, I underlined the importance of trying not to solve a problem right away. In education we always accentuate that there is only one right answer and the faster we arrive at that right answer, the smarter we are. Finally, I detailed the importance of relaxing, removing ourselves from the problem we are trying to generate ideas for, and explained how new ideas will result when relaxation begins.

The final step in introducing CPS to my students required an explanation of how to find, analyze, develop, and put into action a valuable solution, or simply put a plan for action. During this stage I showed a PowerPoint presentation that outlined process planning (See Appendix E). This presentation included: a definition of process planning, explains when you are ready for it, do you have the tools to follow through with a process plan, setting up a plan for action, organization of a plan, and how to take action. As a science teacher I related this to how formal lab reports would be submitted and I identified the major components of a lab report and compared that to process planning.

Upon the conclusion of my introduction of CPS, I modeled the entire process by working on an individual student's problem that they wanted the class to help them develop solutions and a plan of action for. I took the role of the facilitator, introduced the

client and their problem, and explained that the class would work as the resource group. We worked through the students' problem by working through the building blocks of CPS: Clarify the Problem, Explore the Challenge, and Select and Strengthen Solutions. Upon the conclusion of this phase of my strategy for teaching students CPS, I then asked the students how we could use this process in class to assist in the learning of scientific content. A number of ideas were generated, the expectations for the class were outlined, and it was now time to begin the introduction of the course curriculum.

IV. Using CPS During Class Instruction

At the beginning of each Topic in Living Environment there are sets of vocabulary words that are essential for students to learn to establish background knowledge. To break from the tradition of having students memorize the definitions, I engaged the students in variations of Visual Connections, Card Sort, Forced Connections and Word Dance to get their mental wheels turning and get them to think creatively in order to gain insight into the key vocabulary words. For example, if the key vocabulary word was mitochondria (the definition is the powerhouse of the cell that creates energy), I might show the student a picture of a power plant and ask them to come up with their own working definition for the mitochondria (Forced Connection). Using Visual Connections I might ask the questions: What do you see, What does this building do, How do you think this power plant might work in your body, or Why does the human body need its own power plant? In order to expand on these experiences I would then have the students write a working definition for the class on a poster board, draw a different picture depicting the role of the mitochondria in the body, have them present this information to the class (each student would do this for a different vocabulary term),

and then hang these definitions and pictures on the walls of the classroom. Engaging students using these tools allowed me to make the class fun, create a relaxed classroom, and actively engaged the whole brain to facilitate student learning.

After the key vocabulary was introduced and background knowledge was instilled in each student, I then presented the course material in a lecture format using PowerPoint presentations and fill in the blank note sheets that were consistent for each academic school year. The material presented was consistent with the New York State Standards that had been established for the Living Environment Curriculum. Throughout various times during the presentation of notes I would use tools such as Excursion, SCAMPER, and the Morphological Matrix (Idea Box) from CPS in order to inspire, motivate, produce novel ideas, and open up the creative boundaries of my students. On some occasions I may use role-playing to tie relevant concepts together. Using the cell and its organelles as an example, I assigned each student an organelle, required them to make a costume representing the appearance of that organelle, and had students work in groups to perform a skit identifying how all of the organelles worked together to sustain the homeostasis of the cell. One student was chosen to tour the cell, thus visiting each organelle to determine its function within the cell, resulting in the spring boarding of ideas off what the observer notices by the role-playing of the student organelles. As a class we would then discuss the experience, review the content covered during the Excursion, and discuss any ideas that may have been inspired from the exercise.

During the debriefing of the Excursion, immediately following the exercise or during review of the Topic content, I would use SCAMPER to generate more ideas, stretch student thinking, and spark creative connections between class activities and the

content we were covering. SCAMPER, which stands for Substitute, Combine, Adapt, Modify, Put to other uses, Eliminate, and Rearrange, uses a series of questions designed to stimulate ideas during divergence. Again using the cell as an example I may ask students these questions: what other materials could have been used, how can you combine cell parts, how is a cell like the human body, or what other uses might a cell have? I was not limited as a teacher in the types of questions I would ask nor were students limited in the responses they could give. Academic freedom was securely implemented into my classroom.

Since labs were a necessity for students to earn course credit, I continuously divided students up into lab groups to complete a series of lab activities throughout the year. During laboratory exercises, I would give students one question or problem that they would have to work on by using the entire CPS process. For each topic covered the questions would be different but, using the New York State Standards as the basis for my development of the questions, the question always centered on a main focal point that was required to know in order to pass the Regents Exam at the conclusion of the school year. Once students divided into their own lab groups I would give them a question they would have to research at home by using their textbooks or the Internet in order to gather data on how to solve the problem. When the students came into class the next day I would check to make sure each student had completed their research, broke them into their resource groups and let them use the CPS process to develop a plan of action to solve the problem. For example, when we were discussing transport mechanisms in the cell I had students research the question, how do materials move between the intracellular and intercellular environment? I outlined the materials they could use or might need in

the experiment, had them research the question, then follow the guidelines previously established for using CPS to generate solutions for the problem statement, and then develop their plan of action. Before students would execute their experimental procedure I would review their process plan to insure they had developed a fundamentally and conceptually sound process plan. Upon the completion of their experiment I would have groups discuss the experimental procedure they followed, share with one another what they learned, and then had them complete the required laboratory questions. These questions were on the lab reports given to students using the traditional teaching method in the 2002-2003 and 2003-2004 academic calendar years. The lab report included the background information, the hypothesis or problem statement, the procedure for completing the experiment, a results section, and discussion questions. Using this method for completing labs required students to think creatively in order to examine and bring relevance to scientific content. Instead of following a given procedure designed to get the right answers, students were required to think, to think outside of the box, in order to make their own connections. In short, I believe this was the most important step in getting students to think creatively in my classroom.

Throughout the year I consistently gave students homework assignments, tests, and quizzes in order to assess the amount of content that was retained. In the past when students would ask me a question about something they needed assistance with (usually they just wanted the correct answer), I would refer them back to a section of their notes or a page number in the book where the answer could be found. With the experimental group I tried something different, the use of brainwriting and the help of peer groups to uncover the ‘mystery’ behind difficult scientific content. Having three years of

experience teaching, I usually knew which questions and content would be most difficult for students to comprehend. Therefore, I would divide students into cooperative learning groups at various times in the year, or when a topic area became a sticking point, and had students engage in the brainwriting technique. Using the brainwriting worksheet I would have students write down a problematic content area in the statement of challenge area and then fulfill the execution of the brainwriting exercise. Instead of relying on the teacher for the answers, students were now relying on their peers to generate solutions to a specific problem. This helped me to alleviate the number of times students encountered problem areas and helped me to establish a classroom based on trust and respect. Again the responsibility for learning material was taken out of my hands and the responsibility was placed in the hands of the students. I was requiring students to take ownership in the learning process.

Upon the conclusion of each Topic area, I would engage students in a modification to the Targeting tool used during convergence. My modification of the tool was designed to determine what areas students felt comfortable with and what they felt they needed more help with at the end of the year when review began in preparation for taking the Regents Exam. This tool was more of an assessment of content areas I was strong in delivering as well as exposing areas of weakness. To complete this activity I would have students use arrow shaped post-it notes to write down their content areas of strength and weakness. Once they had done this they would place their post-its on a dartboard. Areas of strength were closer to the bull's-eye and areas of weakness were further away from the bull's eye. Once all students were finished placing their post-its, I examined the board, correlated the results to determine what we needed to spend more or

less time on during review, and made notes to myself on how I could improve my effectiveness in presenting material that students found more difficult to learn. Students felt empowered by this tool because it gave them the chance to evaluate me and it provided them with the opportunity to assist in making the curriculum more fun and interesting for future students who might enroll in my course.

At the onset of using CPS in the classroom my primary goal was to have students use CPS effectively, and to become independent problem solvers who could apply CPS to real life challenges. In order to determine if I was effective in my use of CPS I concluded my experimental study by having students solve this problem statement, It would be great if I could teach ecology to my fellow classmates. Students then divided into their own cooperative groups and worked on generating ideas as to how they could fulfill the role of the teacher in the classroom as they taught a specific content area in the topic of ecology. Using the entire process of CPS students developed a creative lesson plan to teach their designated content area. Upon completion of their process plan, each group of students was then required to implement their lesson plan by teaching their required topic area to their peers. Most students followed the same strategies I used for presenting class material: introduce vocabulary, present notes, lab activity, and administer an assessment tool. However, their creativity was clearly observed in the lab activities that they generated. Two groups created games, one based on the concept of Monopoly and the other chess, one group performed a scavenger hunt using the school grounds for their environment, and another group used a modification of the hit reality television show *The Apprentice*, to enhance the learning of ecology. At the end of each group's lesson plan it was clear that they could solve their own problem without the help of the teacher,

students understood how to use the CPS process when confronted with a problem or challenge, and students used different tools and techniques to help them solve the problem.

There are a number of different ways CPS can be used to deliver educational content. I merely presented a framework of how I taught each Topic area and provided just a few examples of how CPS tools can be manipulated in order to foster creative thought and inspire students to learn in the classroom. CPS can be used for tests, quizzes, homework, labs, projects, review, and evaluation. There is no set plan, nor should there be, for how a teacher uses and implements CPS in the classroom. My ultimate goal was to motivate and inspire students to use CPS to solve their own real life problems. The common language provided by CPS provided two clear benefits: it provided clear definitions and labels for problem-solving operations so that students can retrieve them when necessary and the common language of CPS allowed for easy transition from content area to content area and from school to the real-life setting.

Results

During the experimental study several pieces of data were collected to determine the effectiveness of implementing CPS in the science classroom. Data was collected through a teacher feedback form, student feedback form, and a compilation of student averages from Report Cards at the end of each marking period (1st Quarter, 2nd Quarter, 3rd Quarter, and Final Quarter).

I. Report Cards

At the conclusion of each academic school year I made a copy of each class report card in order to gather the data required for the experiment. The data collected included:

number of students participating in each group, number of teaching days required to complete the curriculum, 1st Quarter Averages, 2nd Quarter Averages, 3rd Quarter Averages, 4th Quarter Averages, Overall Averages, Regent's Exam Averages, and the Number of Students Achieving Mastery (students who achieved a score of 85% or higher on the Regents Exam). Table 4 depicts the data that was collected for the experimental and control groups.

Table 4: Quantitative Analysis of Student Averages

	Control Group: Traditional Teaching Style	**Experimental Group: CPS**	**Change**
Number of student participants	55	80	+25
Number of days to Complete Curriculum	172	163	-9
1st Quarter Average	81.5%	81.2%	-0.3
2nd Quarter Average	78.6%	81.9%	+3.3
3rd Quarter Average	79.3%	81.5%	+2.2
4th Quarter Average	79.8%	81.9%	+2.1
Overall Average	79.9%	81.9%	+2.0
Living Environment Regents Exam Average	76%	79%	+3.0
Mastery Level	25%	32%	+7.0

Summary

Overall, the results showed that students who participated in the experimental group, or the group exposed to CPS, achieved higher averages for the 2nd, 3rd, & 4th

Quarters, obtained a higher overall average, scored higher on the New York State Regents Exam for Living Environment, achieved a higher percentage of students who attained Mastery Level on the Regents Exam, and required nine fewer teaching days to complete the content required in the curriculum. Results of the experiment also show that the control group scored higher during the 1st Quarter than did students who were part of the experimental group.

II. Teacher Feedback Form

The Teacher Feedback Form (See Appendix F) contained a number of statements that were used to determine the effectiveness of implementing CPS in the science curriculum. The statements were: (a) The students were able to grasp the CPS language; (b) The students were able to use convergent and divergent tools; (c) The students were able to recognize the stages of CPS; (d) There was a change in the creative problem solving skills of my students; (e) Students were able to think independently and more creatively; (f) Students were able to solve problems using CPS; (g) The teacher modified the tools used in CPS to meet the needs of the student. The scale of responses was 1 = rarely, 2 = occasionally, 3 = sometimes, 4 = often, and 5 = always. See Table 5 for the results of the survey.

Table 5: Teacher Feedback Form

Statement	Response
The students were able to grasp the CPS language	Sometimes
The students were able to use convergent and divergent tools.	Often
The students were able to recognize the stages of CPS.	Sometimes
There was a change in the creative problem solving skills of my students.	Often
Students were able to think independently and more creatively.	Often
Students were able to solve problems using CPS.	Often
The teacher modified the tools used in CPS To meet the needs of the student.	Often

Summary

Results indicate that students were able to use the tools involved in CPS to help them solve a variety of problems when they were introduced into the classroom. After learning CPS they were able to think more creatively and increased their ability to think independently when working in groups or alone. I noticed that students were able to apply CPS to a wide array of problem situations and use what they had learned in order to solve real life and classroom challenges. However, students did have a hard time using

the language of CPS and their ability to recognize the various stages of CPS was sometimes hindered.

III. Student Feedback Form

Upon the completion of the 2004-2005 school year, members of the experimental group were asked a series of questions designed to evaluate the effectiveness of the course, CPS, and the teacher (See Appendix G). The students were asked to answer a series of yes and no questions that included: (a) My teacher helped me to learn CPS and how to apply the process in order to solve problems; (b) CPS is fun; (c) I used the charts and posters to help solve classroom problems; (d) I understand the charts and posters used for CPS; (e) I enjoyed the warm up exercises because they allowed me to unveil my creativity. Students were then asked to respond to a series of questions using a rating scale where 1 = rarely, 2 = occasionally, 3 = sometimes, 4 = often, and 5 = always. The questions were: (a) Did the materials meet the needs of the class; (b) Did the tools worksheets aid in understanding CPS; (c) Was the teacher instructional material easy to follow; (d) Were the lessons easy to follow; (e) Were the materials successful in teaching CPS; (f) Did the learning environment foster creativity. The student feedback form then asked to write down how they were affected by CPS or how the course could be improved in the future. See Table 6 for the mean and range scores.

Table 6: Student Feedback Form

Statement	Ratio Yes	Ratio No
My teacher helped me to learn CPS and how to apply the process in order to solve problems.	72/80	8/80
CPS is fun.	76/80	4/80
I used the charts and posters to help solve class problems.	73/80	7/80
I understand the charts and posters used for CPS.	72/80	8/80
I enjoyed the warm up exercises.	78/80	2/80

Statement	Mean	Range
Did the materials meet the needs of the class?	4.5	4-5
Did the tools worksheets aid in understanding CPS?	3.7	3-4
Was the instructional material easy to follow?	4.7	4-5
Were the lessons easy to follow?	4.3	4-5
Were the materials successful in teaching CPS?	4.0	3-5
Did the learning environment foster creativity?	4.2	3-5

Summary

Students determined that using CPS and the warm up classes were fun and that they were essential in establishing a positive learning environment. A majority of the students found the materials, posters, charts, and worksheets helpful in assisting them throughout the process and enabling them to solve problems encountered while in the

classroom. Students found the course to be challenging, motivating, and easy to follow. Students were able to follow and comprehend the lesson plans throughout the year and the majority believed the materials were useful in helping them acquire the skills necessary to use CPS. Students were also asked to write down any feelings or impact they believe using CPS had in the classroom and they had this to say:

Sample of Student Quotes:

- "Finally, a teacher who let me express my ideas and share my thoughts."
- "Sometimes I came to school just so I could be in your class."
- "Learning in your class was fun."
- "CPS gave me power."
- "I felt safe. I wasn't scared to share any of my answers."
- "I enjoyed science for the first time in my life."
- "I liked brainstorming. Who would have thought we could answer our own questions?"
- "Freedom."
- "I liked to play with your materials without you getting mad."
- "You listened to our ideas, helped us when we needed it, but let us explore our own interests."
- "I learned how I can solve problems on my own."
- "I always left your class in a good mood. I wanted to learn more."

When asked how to improve the course students shared these ideas:

Student Quotes:

- "Why can't you tell more teachers to use CPS?"

- "Do warm ups like the cab driver everyday. Their fun and they get the class started."
- "Don't make us do warm ups we don't feel like doing."
- "I didn't like doing the background research for labs. It was too hard. Give us the regular labs to study."
- "Be stricter."
- "Let us pick our own working groups all the time."

Interpreting the Experimental Study

As a result of the experiment I determined that using CPS in the science classroom benefited my students in a number of ways. Students were able to use and understand most of the CPS language to solve their own problems, students could apply convergent and divergent tools in order to facilitate the learning of scientific content, class participation increased, there was an improvement in students classroom work, and the classroom climate was enhanced

Problem Solving Skills

When I first became a teacher I wanted my students to feel comfortable in approaching me to discuss aspects of their personal lives which may or may not have an impact on the way they perform in the classroom. Teenagers experience their own real challenges that may involve themselves, their friends, family, or their community. Most teachers disregard the problems students face in their life, thus creating a roadblock for students in the learning process. I wanted to provide students with a process that would help them to generate solutions to their problem in the hope of improving the learning capabilities of the students while they were in my classroom. Therefore, I taught them the

basics of CPS to assist them in solving problems they would encounter inside and outside of the classroom. From this study I concluded that students were effective in applying the stages and components of CPS to varying levels. Students clearly had an easier time understanding the problem and generating ideas but they had a much more difficult time generating a plan for action. In part, this was a result of the predisposed notion that there is only one acceptable answer or way to come to an answer and students feared that I would evaluate them on whether or not the answer was right or wrong. Throughout the year I had a difficult time getting the students to understand that I was more interested in the way that they worked through a problem rather than the answer they generated. In time students did learn that problems can be solved in many ways, there can be more than one answer to a problem, and that our failures were really opportunities for the trial and learn concept previously discussed.

I also introduced CPS to the classroom because New York State is placing an emphasis on the development of process skills as well as content knowledge in today's student. Corporations and society also stress the importance of creative thinking, problem solving, goal-motivation and teamwork in their employees. Therefore, I took it as my responsibility to model and practice CPS in my classroom in order to develop these skills in my students. Upon the conclusion of the experimental study students showed an improved ability to work as a team, set goals, to think creatively, and to work through the stages of CPS in order to seek resolutions to problems.

When students were subjected to the development of a process plan to solve a lab question, I determined that students were able to apply CPS in order to come up with a way to derive an answer for the question. It was apparent that students were able to move

through the process under my supervision, but it was evident that they were unable to internalize the entire CPS process. Students were aware of the stage they were applying, were able to identify when to move to the next phase, and they were better able to monitor themselves and their problem solving ability. However, they consistently needed reminders, from either myself or the CPS posters and charts scattered throughout the room as to which phase of CPS (in addition the strategies and language of each phase) they needed to proceed to.

I judged the overall comprehension and comfort students had for using CPS when they were required to teach a topic in ecology at the end of the year. For the most part, each group was successful in using CPS to solve problems they encountered in the classroom. But, I was not able to pinpoint how successful students were in using CPS to assist them in solving problems that plague their own lives. In part, this was a result of my failure to delve into the personal lives of my students so that I could witness their problem solving skills when the opportunity arose. Also, students did not relate on their student feedback forms how they were able to use CPS in the real life setting.

CPS Tools

Throughout the year most of the tools in CPS were introduced into the curriculum. Tools such as Word Dance, Brainstorming, Brainwriting, Morphological Matrix, Targeting, Excursions, Scamper, Highlighting, PPCo, Forced Connections, V.I.R, PCA, SCAMPER, and Card Sort were used with simple modifications to facilitate the learning process. Students understood the requirements and directions of how to apply the tool, but they had a more difficult time matching and recalling the appropriate names of the tools and the desired outcome produced by the use of a specific tool. Students

would identify tools not by name rather how they were incorporated in previous lessons. Students tended to favor the use of Brainstorming with post-its because it tended to be the easiest tool to use and it required less working materials.

In my evaluation of the entire year and the manner in which I used CPS throughout the curriculum, I found that I used more divergent tools than convergent. In part, this was due to the popularity of Brainstorming amongst the students. This may indicate that students did not practice convergent tools as much, or that convergent tools were more difficult to apply into the classroom. Time restriction may also have played a part because class periods were only 40 minutes and we may not have been able to work through convergent phases of CPS.

When tools such as brainwriting were used to in the cooperative group setting to help generate solutions to specific problem areas in class I found that students were able to build on the ideas generated from their peers and discovered the answer to the problems they were facing. Throughout the year I used a number of the tools found in Appendix A, with my own modifications, at different stages in the teaching of class material. By doing this I was able to remove some of the responsibility I had in assisting students when they completed assessment tools (labs, homework, and quizzes) and turned that responsibility over to the fellow students. By having the students use CPS tools when a sticking point was reached, students were asked to rely on their peers for the help I gave in the past. This resulted in more students completing assignments and resulted in an increase of homework, test, and quiz scores because of the enhanced ability to solve problems independently.

Class Participation

I used certain aspects of CPS in order to get students more involved in the learning process and to increase student responses in class based on their previous knowledge, key learnings, and insight from research they were required to conduct throughout the year. My immediate goal was to engage more students by providing a number of activities where all levels of participation were required. By giving students time to prepare their own process plan for completing labs, invoking the questioning method previously listed in how to I could promote creativity in the classroom, and using various tools to increase the retention of scientific content, I found that student interest and participation in the class greatly increased. Students were receptive to the concept of thinking on their own and took pride and ownership of the problems presented in class. As students became more comfortable with CPS and the tools involved, they were more apt to share wild and crazy ideas. I determined that every student wanted to share their own ideas, thoughts, and questions and the use of CPS was the key to unlocking their feeling of uneasiness when confronted with a teacher who used traditional teaching style methodologies. In taking ownership of the learning process students became motivated to learn and as this motivation increased, so did the enthusiasm to participate. CPS provided students with a way to extend their learning, to branch out new ideas and topics, and to bring relevance to scientific content.

CPS gave students the freedom to make their own decisions about how to solve a problem. Most students designed their process plans based on their interests outside of the classroom. Students believed that they were helping me to write the days activities because I let the class flow in whatever direction they determined. Students felt that they

had freedom, this freedom gave them power, both resulted in an increase in class participation.

Throughout the year I require students to work in cooperative groups that ranged from 2-6 students per group. At the beginning of the year students appeared withdrawn if they were part of a group that did not include any friends and refused to participate or contributed very little when the CPS process was being used. At the end of the year there was a drastic increase in participation amongst cooperative learning groups as social barriers were broken down as a result of the increased trust students acquired when using CPS. Students began to ask each other for help, respected one another's opinion, they built upon each others ideas, and relished in the opportunity to openly communicate their thoughts and feelings in the classroom.

Classroom Work

For the first three years of my teaching assignment at Depew High School I found that students gave up when confronted with a difficult assignment or simply asked the teacher for the answer. After using CPS with the experimental group I found that students became more patient when confronted with the same problems and they were more determined to take the time needed to solve their own problems. Students became more persistent and patient, explored the whole situation, and generated more ideas to work to their own solutions. Students learned to take a step back, gather all the background knowledge they could about a problem, and tended to become less frustrated when the work became more difficult. Observing the trends in Table 3, student performance of the experimental dramatically increased in comparison to the control group as the year progressed and as a result an increase in the students meeting Mastery Level on the

Regents Exam (the basis by which the District identifies successful teachers) was achieved. The overall time students spent on assignments increased which resulted in the increase of student performance on labs, quizzes, tests, projects, and homework. An improvement of student writing levels and the ability to write complete sentences that clearly expressed student's thoughts was also identified.

Analysis of the student's report cards indicated that the experimental group scored lower than the control group in the 1st marking period only. I attribute this to the novelty of using CPS in the classroom and the time it took to overcome the discomfort of trying something new.

Classroom Climate

Teachers continuously hear students complain about the subject matter and often they wonder why they need to know science and how they will use science in their future life if they don't wish to pursue a career that requires scientific literacy. After using CPS for the entire year students no longer griped about the course content, instead they asked how can we learn more and what can we do about making the class more fun. Students began expressing their interest and willingness to solve more problems in the area of science and life.

As the rules of divergent thinking took hold in the classroom, students realized they would not be judged by me or their peers. Therefore, they felt safe in the classroom and motivation became part of their persona. Since CPS provides the opportunity for significant and meaningful input, students were motivated to put forth greater effort. Students thus gained confidence in themselves and the expression of their ideas so they became independent learners. When I listened without judging the student or their ideas,

they felt empowered to know that their voice meant something. Student fear decreased, student trust and respect increased, and a positive learning environment flourished.

When the classroom climate was developed I noticed a trend that students made a greater effort to come to school just to be in my class. It didn't matter what mood students had when they entered the classroom, they would leave my class smiling, laughing, and feeling a sense of happiness. Students were eager to put forth maximum effort, recognized that failure wouldn't be a term used in our class, and were therefore more willing to take more risks in order to learn more. The praise first concept and the 8 positives: 1 criticism ratio made students focus on the positive. As a result of the safe and positive learning environment that was promoted students became producers of knowledge.

Limitations

1. I only spent two weeks teaching students the components of CPS and how it can be used to solve real life and classroom problems. It was evident that this was not enough time to make students comfortable enough to recognize how and when to move through the stages of CPS.
2. I addressed only one student problem with the experimental group in order to practice the usage of CPS to solve a problem. Due to the time constraints placed on teaching CPS and the Living Environment, not enough time was focused on using CPS to solve more student problems; therefore, students seemed uneasy with the process until they were given the opportunity to practice CPS in order to become more comfortable and efficient when working through the process.

3. During the practicing of CPS we only used Brainstorming and highlighting as the tools when working through the process. I never introduced the specific names of other tools we used during the school year or the modifications of the tools that I incorporated into teaching the curriculum; therefore, students were not able to identify the names or the specifics of completing divergent and convergent tools.
4. I never identified what tools students enjoyed throughout the year. I could have made a better effort to assess student progress in using divergent and convergent tools at the midpoint of the school year in order to determine the tools that were most and least effective in assisting students while using CPS.
5. Some students were added to the class after I introduced CPS to the class. As a result, these students were uncomfortable with using or working through the entire process while working in the laboratory setting. A better effort could have been made by the student and the teacher to get these newly added students up to speed on the CPS process.
6. Throughout the study absenteeism increased during the winter months and some students missed the opportunity to practice the process and its tools. In an attempt to catch these students up with the class, traditional teaching methods were used to teach scientific content. This was more a result of a lack of resource group members that were needed to complete the CPS process when completing class activities.
7. As a teacher I wanted students to work with all of their classmates, not just those who they were friends with or had close personal relationships with. As a result students were sometimes forced to work in cooperative groups that they did not

feel comfortable with and idea generation was suppressed. In my attempt to break down the barriers created by peer groups in the school setting, I may have spurned the opportunity to expand creative horizons.

8. I did not get to choose the number of participants for the study or the student make up of the control and experimental groups. Therefore, the experimental and control groups could have had more than one variable (the only intended variable that was changed was using CPS as a teaching process) that affected the final outcomes that were used to measure the effectiveness of using CPS in the classroom.

Recommendations

The recommendations presented reflect possible future studies or questions that I would like to see researched as a result of my observations when completing this study.

1. While completing this study I gathered data that supported the effective implementation of CPS in solving problems encountered in the science classroom. However, I noticed that students did need my help at times when working through the entire process. I recommend a study to be conducted that assesses the ability students have to solve real life problems on their own and to solve problems in other content areas in the educational field.
2. The study also suggests that students felt more comfortable when using divergent tools, and convergent tools were more difficult to apply in the classroom. A subsequent study could be performed to determine why students feel more

comfortable using divergent tools or determine a method to improve the effectiveness of implementing convergent tools in the classroom.

3. The results of the study also found that students were more motivated to work through difficult problems as the year progressed and they gained more comfort in using CPS. I recommend that a study be conducted to assess the current motivation level of students within the school setting in order to determine why motivation appears to be at an all time low and when the motivational level of students began to decrease. The study should also determine other ways to increase student motivation in order to maximize student performance in the classroom.
4. In the experiment I used a number of tools but did not share the specific name of the tool in class. At times students were unaware that they were using a tool involved in CPS and were unable to recognize the names or the directions for completing the tools when I had them complete the feedback form at the end of the year. I believe I could have done a better job assessing the effectiveness of each tool used and how it affected student performance. Therefore, I recommend a complex study that teaches students specific tools, identifies the proper terminology and practice of completing the tool, and then requires students to practice these tools using real life situations. The experiment should then use these tools at specific times during the school year to teach different aspects of the curriculum. In the end I would like the experiment to generate results identifying when and where specific tools should be used when teaching content material. In short, the experiment should identify which tools to use when teaching

vocabulary, completing homework assignments, tests, and quizzes, when teaching specific content, and so on. The study should also list specifically how each tool should be used to maximize student performance.